

HYDROLOGIC STUDY OF JEWEL CAVE/WIND CAVE

E. Calvin Alexander, Jr.
and
Marsha A. Davis
Department of Geology and Geophysics
University of Minnesota
Minneapolis

Objectives

The hydrologic study at Wind and Jewel Caves has the following objectives: 1) to evaluate the water distribution within these two park areas; 2) to determine the effects of human impact upon the natural hydrologic system; 3) to document any detrimental effects to the water quality; 4) to document any instances in which the cave environment is adversely affected by the quality or quantity of the water present; and 5) to suggest options to change present water use practices, if necessary.

Methods

The objectives of the research are being accomplished in three, overlapping phases which were outlined in the original proposal. Phase I involves the compilation of the available information on the caves' location, geology and hydrology and correlation of that information with the surface artificial features. The goal of Phase I is to compile available information that is currently scattered in various files and individual records and memories.

Phase II is as complete as possible a chemical characterization of the surface and subsurface waters in the two areas. This phase involves chemical analyses of major cation and anion species, selected trace elements, synthetic organic compounds and/or natural and anthropogenic isotopic species in the waters.

Phase III is an investigation of infiltration of surface waters into the caves. Correlation of the chemistries of surface and subsurface waters are yielding some information in this phase but the major tool is dye trace studies.

The details of all three phases are available in the proposal and will not be repeated here. Our major goals for this 3rd year of the study are to complete our water sampling and to conduct a final dye trace at both Wind and Jewel Caves.

Results

During the third year of the study we have continued to expand the data base of Phase I with surveying and drafting maps of Cold Brook Spring, north of Hot Springs, and Cascade Springs, south of town. Both springs have proven on close examination to be complex springs with waters of different temperatures and chemistries emerging at each spring complex. A map of Cascade Springs is shown in Figure 1. Cascade Spring has two sets of resurgences. The upstream set of three resurgences have higher temperatures and sodium chloride contents but lower pHs than do the downstream springs. These springs are the headwaters of Cascade Creek which drains into the Cheyenne River.

Cold Brook is also a complex spring. One rise emerges from a distinct point at the base of a cliff and a more diffuse spring emerges in the valley floor. The spring forms the perennial head of flow into Cold Brook Reservoir. ^{14}C and tritium data, as well as the water's low temperature are indicative of a short underground residence time.

It appears that the major springs at: Buffalo Gap, in and around the town of Hot Springs, and at Cascade Springs are all complex springs with water from several distinct reservoirs emerging at each area. These areas are thought to contain the resurgence point(s) for waters sinking at Wind and Jewel Caves. The complexity of the springs means that we must ultimately identify not only which spring or springs are the actual resurgences but we must identify which part of which springs are the resurgences.

The chemical and isotopic sampling has concentrated on: 1) repetitive sampling of previously established sample points to look for time variation in the water quality parameters, 2) filling in any remaining gaps in our sample network, and 3) sampling designed to elucidate the water quality trends discovered to date. About 35 samples have been collected and analyzed for cation and anion concentrations. Nitrate samples continued to be taken from Methodist Church, Mule's Ear and Minnehaha Falls in Wind Cave. Nitrate levels during the summer of 1987 were not as high as during 1986. The Methodist Church data are shown in Figure 2.

Two dye traces have been initiated during the summer of 1987, one at Jewel Cave and one at Wind Cave. The Jewel Cave trace is a Rhodamine WT trace designed to confirm the Fluorescein trace conducted during 1986. Dye was injected into the runoff from the Visitor Center parking lot during an "artificial rain storm". The dye began emerging in the cave at two points, survey station R44 and the Spelunking Tour Flowstone drips, within a few days and continues to emerge in a long pulse. Figure 3 shows the data from one of the positive sampling points in Jewel Cave.

The second dye trace is a major attempt to locate the resurgence of the water that sinks in Beaver Creek, approximately 2 miles north of Wind

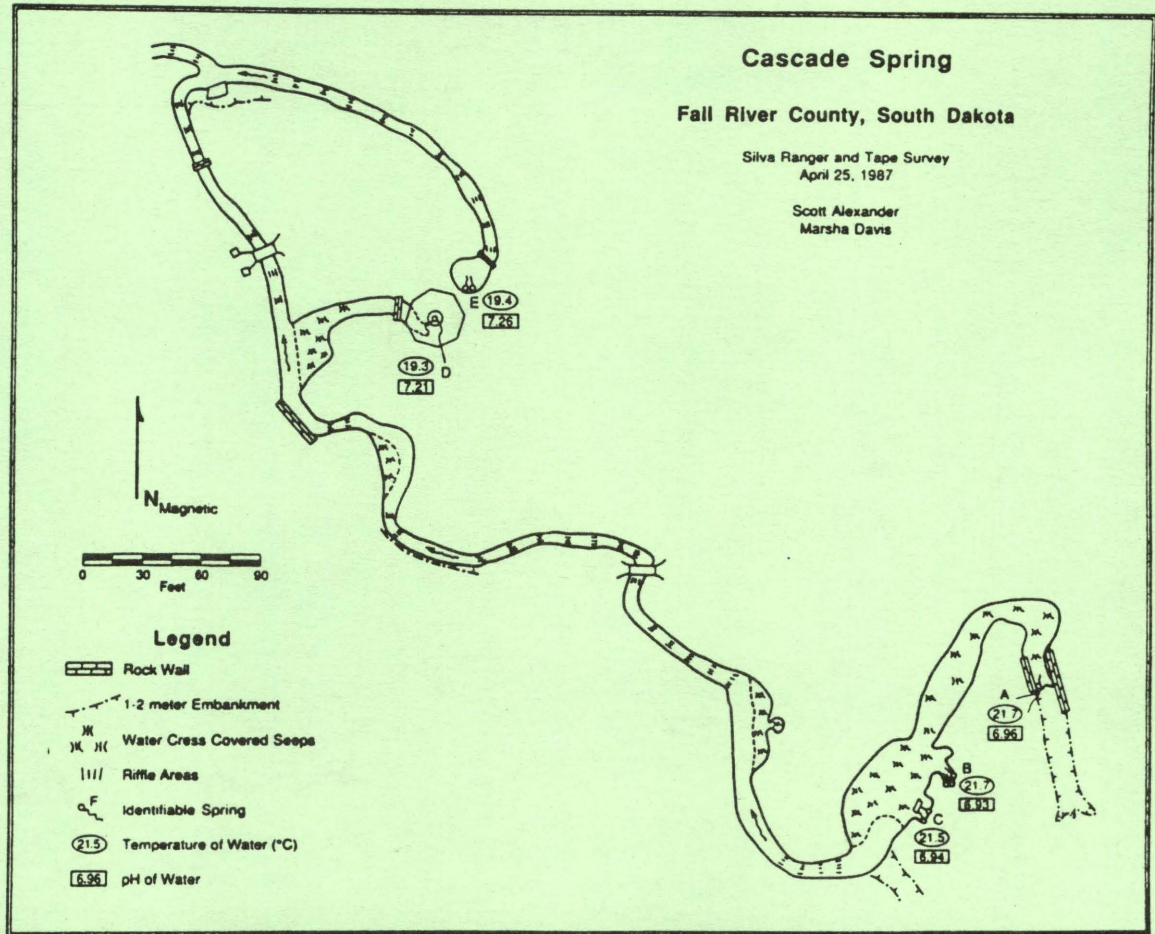


Figure 1. Plan View of Cascade Springs.

METHODIST CHURCH

WIND CAVE

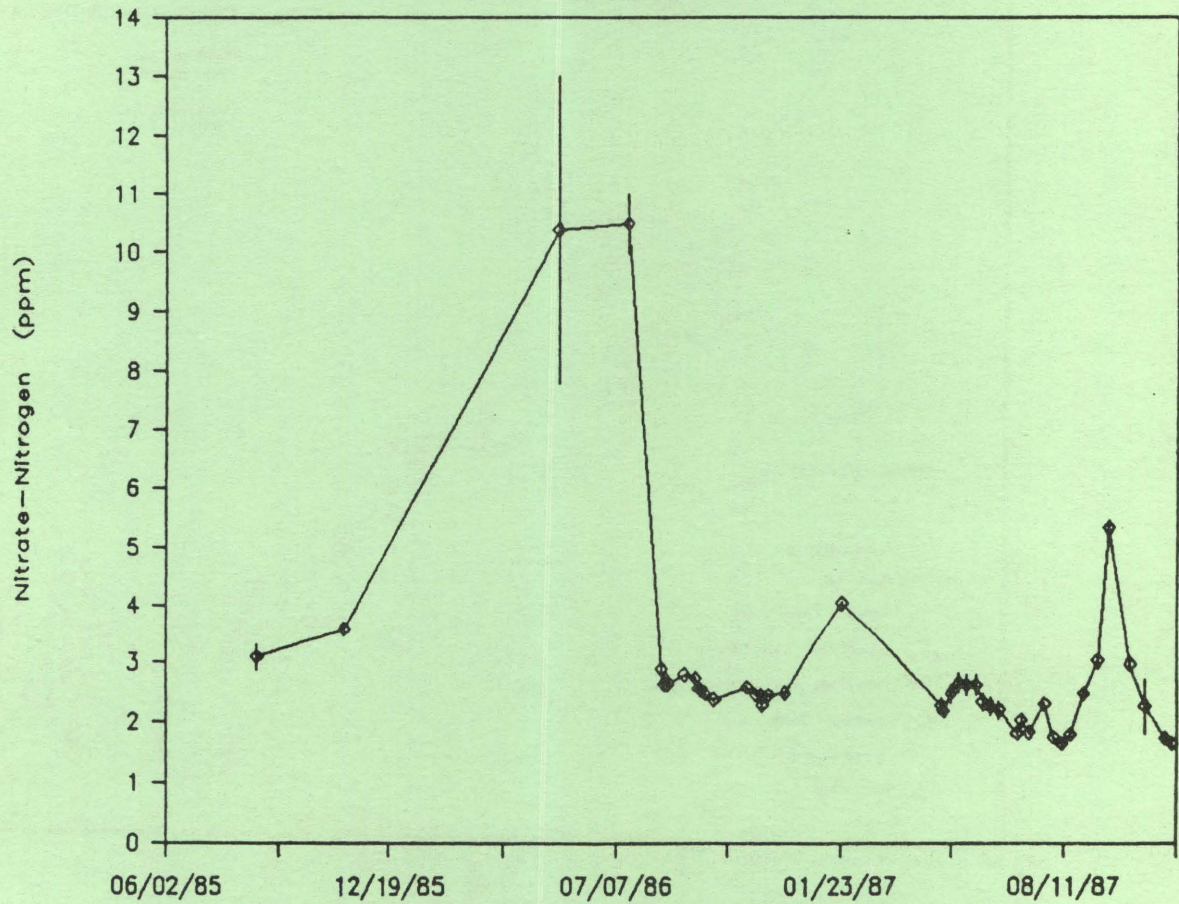


Figure 2. Nitrate-nitrogen from Methodist Church Drips.

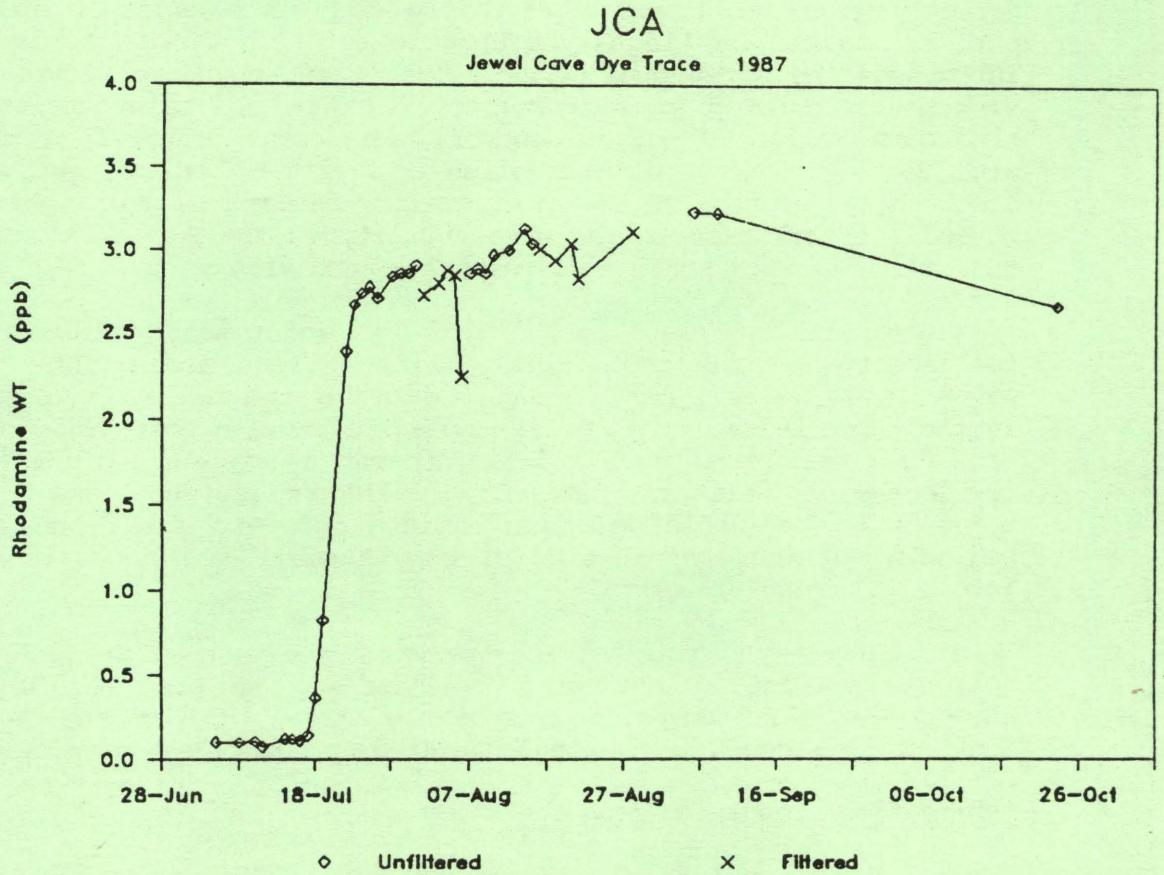


Figure 3. Rhodamine WT Breakthrough Curve for Water Collected at Survey Site R44 in Jewel Cave. On July 7, 1978, 141.5 gm of Rhodamine WT was poured into runoff produced by running water from a fire hose onto the parking lot at Jewel Cave for several hours.

Cave. On June 22, 1987 2.1 kg of Rhodamine WT was poured into the terminal sink of Beaver Creek. Eight spring and well locations have been monitored on a daily to weekly basis for the dye through mid-September. In late August water samples collected from the Wind Cave water well began to show evidence of Rhodamine WT. This well is approximately 2 miles south-southeast of Beaver Creek sink. These data are shown in Figure 4. Four of the original 8 sites are being monitored throughout the winter.

The successful demonstration that Beaver Creek water contributes directly to the Wind Cave water supply well has a series of interrelated public health and legal implications. Any human activity that influences the water quality of Beaver Creek anywhere upstream of the sink has the direct possibility to influence the water quality in the Wind Cave well. Likewise, however, the demonstration of a connection with Beaver Creek should establish a powerful "water right" that may allow the protection of the water quality in Beaver Creek. What happens beyond the Park affects the water quality in the Park and, potentially the health of Park staff and visitors -- and vice versa.

The successful dye trace to the Wind Cave water supply well is entirely consistent with the isotope data we have been accumulating from the water supply wells. The ^{14}C and ^3H data for the two wells is summarized in the table below. Both wells appear to contain post-1960 ^{14}C but the Wind Cave well contains a tritium content consistent with water only a few months old while the Jewel Cave well contains much less tritium and appears to be yielding water that went into the ground near the beginning of the nuclear era (or only a small mixture of recent water into a much older reservoir.)

We are currently organizing and analyzing the mass of data that we have accumulated during the last 2.5 years. We are thankful for the encouragement and cooperation from the staffs of Wind and Jewel Caves and local residents for making this study productive and enjoyable.

Publications resulting from the study

- Davis, M. A. and E. C. Alexander, J. 1986. Impact of Surface Development on Water Quality in Wind and Jewel Caves. Conf. on Science in the Nat'l. Parks, Prog. and Abstracts, Ft. Collins, Colorado, July 13-18, 1986. 242 p.
- E. C. Alexander, J., M. A. Davis, and J. B. Dalgleish. 1986. Dye Tracing Through Thick Unsaturated Zones. Proceedings of the 5th Int'l. Symp. of Underground Water Tracing. Athens, Greece, Sept. 1986. (In press, 1988)
- E. Calvin Alexander, J., Marsh A. Davis, Scott C. Alexander. 1987. Impact of Surface Development on Underlying Cavern Features. 1987 Nat'l. Cave Manage. Symp. Rapid City, SD.

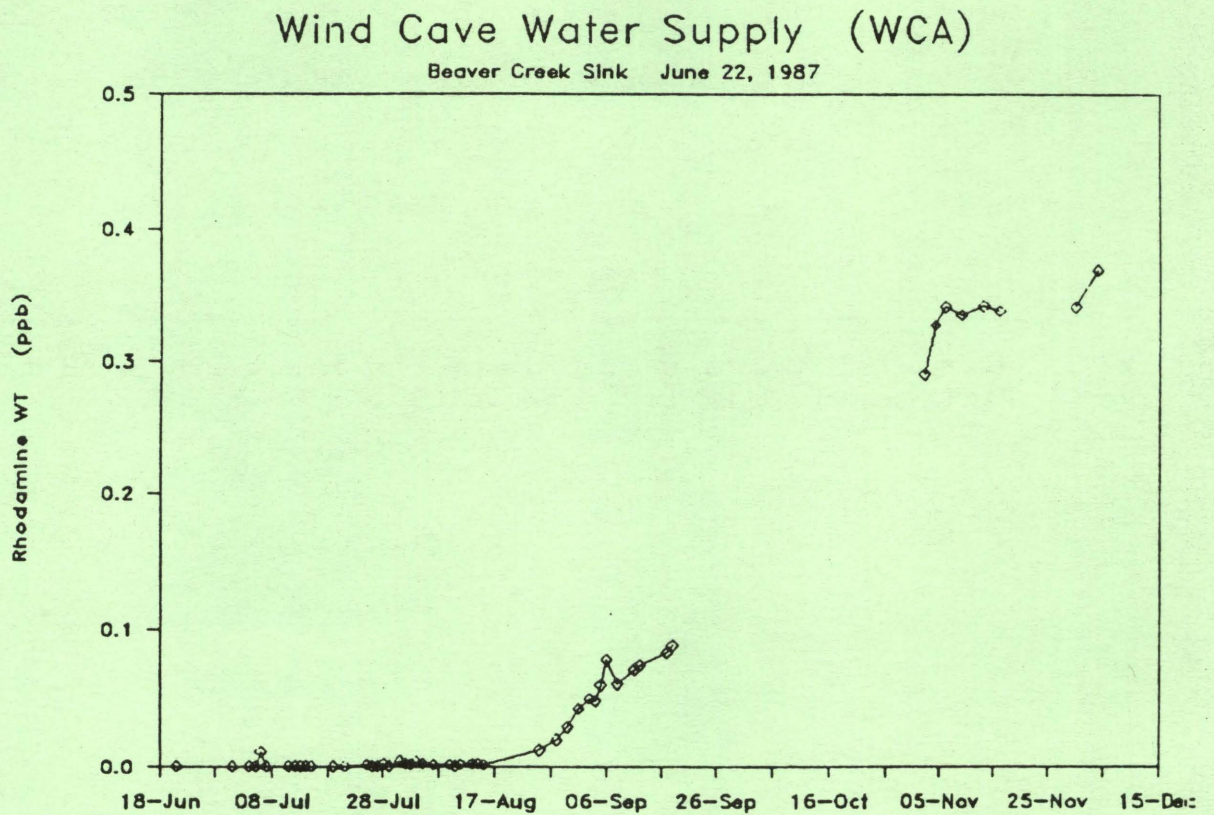


Figure 4. Rhodamine WT Breakthrough Curve for Water Collected from Wind Cave Water Supply Well. On June 22, 1987 2.1 kg of Rhodamine WT was poured into the terminal sink of Beaver Creek, approximately two miles NNW of the well. (The gap in the data from late September through most of October is interval during which Marsha was "drafted" for fire fighting duty in Oregon and northern California.)

Table 1. Isotopic Data from the Wind and Jewel Cave Water Wells.

Date	Wind Cave			Jewel Cave		
	5/10/85	7/18/86	6/21/87	9/12/85	7/19/86	6/20/87
^{14}C	81.45	78.9	80.2	79.73	81.1	80.7
	± 0.68	± 1.0	± 0.9	± 0.85	± 0.9	± 0.9
^3H	- - -	37.3	42.0, 35.0	- - -	3.58	2.4
		± 0.7	± 3.0 ± 1.9		± 0.10	± 0.8

Notes: the ^{14}C data is in units of % of modern and the ^3H data are in TUs (atoms of ^3H per 10^{12} atoms of H.)